david Oakland associates
steam power technology

Steam accumulation – application up-date!

"Steam Accumulation Gives CHP An Added Push To Halt Climate Change"

"There is now widespread acceptance that controlling the emission of greenhouse gasses, particularly carbon dioxide (CO_2), is going to be one of the major challenges facing mankind this millennium" **says the National Energy Foundation.**

Tackling climate change is a huge challenge for all countries of the industrialised world. *"Stabilising CO_2 concentrations in the atmosphere needs global emission cuts of 60% or more over the next 50 years. We need to move quickly to decouple the growth in CO_2 emissions from economic growth".*

Tom Delay, The Carbon Trust's Chief Executive, March 2001.

"Today, I call for new Clean Skies legislation that sets tough new standards to dramatically reduce the three most significant forms of pollution from power plants; sulphur dioxide, nitrogen oxides and mercury."

George W Bush, President of the United States of America, February 2002.

David Oakland* discusses the role that steam accumulation can play in achieving this difficult goal.

The U K Government's Energy White Paper 'Our Energy Future – Creating a low Carbon Economy' sets out its vision to deliver the goals of energy policy including a 60% cut in carbon emissions by 2050. The recently published 'Strategy for Combined Heat and Power' to 2010 demonstrates continued government support for energy-efficient CHP technology. On the CHP strategy, Environment Secretary Margaret Beckett said, *"CHP has an important role to play in achieving our Energy White Paper goals. We want to provide a framework in which business can plan long-term investment decisions with greater certainty. This strategy document does that".*

Reaching target CO_2 reductions will call for contributions from all the major sectors of energy use. Attaining higher efficiency in the use of energy at lower operating cost is a compelling enough preoccupation but for some, government legislation such as the 'climate change levy' and investment tax incentives introduced in the UK in 2001, will be the driving force. As rising fuel prices continue to add to the impact on competitiveness, environmental issues and the acquisition of energy efficient technologies already sit high on the boardroom agenda.

One such technology that continues to play an important role in the modern boilerhouse is **steam accumulation.** Whilst it can often be justified on the grounds of practical advantage alone, its potential to reduce fuel consumption is invariably the carrot that consolidates the case for investment by providing the vehicle for payback. This and legislative measures that limit 'greenhouse gas' pollution will now turn industries attention to looking more strategically at ways to achieve sustainable energy prices and emissions reductions.

The basic purpose of steam accumulation is to eliminate boiler peak loading by providing a reserve of steam to meet intermittent demands. In the charged condition, the accumulator holds a quantity of steam produced as “excess” steam in the boiler at times of low load. When the demand rises, the accumulator discharges and the steam peak is met from storage - rather than from the boiler.

Lower consumption of carbon based fuel will result in lower emission of noxious gases in equal proportion. By means of load stabilisation, steam accumulation enables higher combustion efficiency in the boiler resulting in less fuel being burned. Efficiency improvements can be as high as 5% and modern methods of control figure prominently in achieving this. In many applications, an accumulator would permit the selection of smaller boilers than would otherwise be the case, capital cost would be less, standing heat and power losses would be correspondingly lower and further reductions in atmospheric pollution would result - adding further to the environmental and economic case.

Combined heat and power generation (CHP), which is exempt from the UK Climate Change levy, is the simultaneous generation of heat (usually recovered as steam) and electricity achieved at much higher levels of energy efficiency than that possible as separate entities. The reduction in fuel consumed enhances the economic case for new build developments whilst at the same time cutting the potential for environmentally damaging emissions.

However, those concerned with the design of CHP plant do not always consider the benefits of incorporating steam accumulation into the steam supply system. The purpose of ‘steam storage’ is to provide the means to convert an erratic process steam demand into a steady load. A fluctuating steam demand forces transient operation of the steam generator, which is not conducive to operating at the highest fuel efficiency. This also detracts from optimum sizing of the turbine or engine, which is required for electricity generation. Steam accumulation can provide the answer to marrying these two ideals.

The effect of a steam accumulator is to balance these load variations thus reducing - or even eliminating, the amount of supplementary steam raising capacity that might otherwise be required. The benefits are maximisation of boiler load factor, optimisation of combustion efficiency, lower fuel consumption and therefore reduced emission of atmospheric pollutants. Moreover, the electrical generator can be sized with the benefit of a steadier heat load and can be run continuously for longer periods at full output.

CHP plant 'trips' can be the result of sudden load variations imposed by production requirements or due to a malfunction of any of the major power plant components. In

the latter case, the cause may be in the prime mover (the gas turbine or engine), the heat recovery steam generator, or could be due to failure of the gas compressor or loss of fuel supply, a problem with the steam turbine. Whatever the reason, the production of process steam falls rapidly requiring the standby boilers to fire or in the case of a stoppage of the steam turbine, its by-pass PRV station to open.

It is invariably the case that the standby boilers, supporting auxiliary systems and by-pass facilities are required to be capable of maintaining process steam supplies at maximum demand rate in the event of a CHP plant trip. However, it is inevitable that steam distribution pressure (and temperature) will be lost because of the inherent lag in auxiliary system response. A steam accumulator can largely remove this problem and practically eliminate it altogether because of its ability to discharge steam instantaneously from the reserve held in storage. Pressure in the steam distribution system is held constant whilst the standby boilers are given time to run up to full output and the interruptions that would otherwise occur need not therefore be tolerated.

A typical example of load balancing has been demonstrated in paper mills where paper breakages are commonplace. The accumulator provides the means to dump (store) excess steam as the demand plummets thereby enabling the steam and power generators to be efficiently 'ramped' down. The losses associated with steam blow-off to atmosphere or the costs associated with dump condensing are therefore avoided. On start-up, the demand is sudden and the magnitude of peak loads can be far in excess of the normal production demand. These are met initially from the reserve of steam held in ‘storage’ whilst the generators are gradually run up to match the load.

A UK paper mill also demonstrates the solution to CHP ‘trips’ where an accumulator overcomes all the problems the mill had previously experienced in maintaining power and steam production. The accumulator forms part of a CHP plant that comprises a gas turbine exhausting into a water-tube type waste heat boiler. This supplies steam to the accumulator under ‘demand trend regulation (DTRS) control which automatically and continuously regulates the flow of steam into the accumulator (and hence the demand on the boilers) at a constant rate corresponding to the consumption of the paper machine.

In addition to stabilising the load according to production requirements, the control PLC is also configured to provide the means to absorb excess steam generated at times of sudden load cessation. This potential loss of steam to waste is avoided and the stored steam is subsequently used to meet the instantaneous start-up conditions of the paper machine which occur at steam flow rates well in excess of power related generating capacity.

Furthermore, the regular occurrence of high and low water ‘lock-out’ of the waste heat boiler under load swings has been eliminated. Previously these had been the cause of the total loss of boiler steam to all consumers in the mill.

Steam accumulator installed at a paper mill.

The inclusion of the steam accumulator into the steam supply system at the mill was not only a sound engineering solution to the boiler steaming problems, but it also subsequently provided a useful reduction in capital cost associated with the selection and installation of a new smaller waste heat boiler than would otherwise have been required.

These benefits are in addition to the other gains associated with eliminating the variable and transient loading such as those associated with paper making where response time, process temperatures, and steam quality are paramount.

The viability of the case for steam accumulation relies largely on the magnitude of the pressure differential which, together with the required storage capacity, governs the physical size of the storage vessel. Steam storage systems are usually operated on the 'pressure drop' principle. Generally, a ratio in excess of 2:1 between charge and discharge pressures would offer the basis for favourable practical and economic arguments to adopt the technology but every application would require to be judged on its own merits.

To summarise the advantages:-

- **Gives instantaneous response to sudden load changes.**
- **Maximises power generation and boiler load factor.**
- **Eliminates boiler carry-over and power plant 'trips'.**

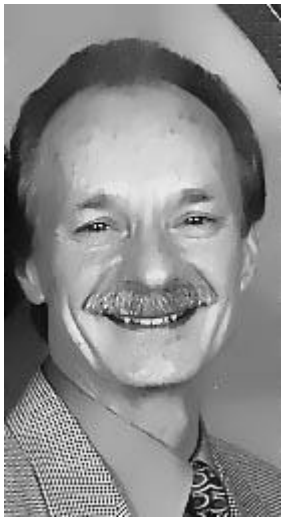
- **Maintains steam quality and safeguards production processes.**
- **Delivers dry-saturated steam. Holds boiler and process pressures constant.**
- **Enables optimum sizing of electrical power generator. Allows turbine to be run continuously at full output.**
- **Minimises requirement for supplementary 'peak load' boiler capacity.**
- **Improves plant efficiency, reduces fuel consumption and the emission of pollutant gases.**
- **Automatic operation and lower plant maintenance.**
- **A typical steam accumulation system will pay for itself on average, within 2 to 3 years.**

Steam accumulation should be recognised as an energy efficient and widely adaptive technology. It can be viewed by designers and operators of power plant as a very real and effective tool for achieving higher operating efficiency, lower fuel cost and the legislative requirements to reduce carbon dioxide emissions.

The author and contact details……..

*The author

David Oakland is a professional engineer and Principal of consultants David Oakland Associates, Dewsbury, England. A 30 year career in steam accumulation began at the Steam Storage Company, working with Walter Goldstern, a specialist consultant in fuel economy and heat storage (Goldstern was a colleague of Dr J Ruth – the man who pioneered the science of steam accumulation). Many will recall his 'Ruths' designs that were adopted for numerous installations worldwide and are still used today.



David's expertise was further developed with an established mechanical engineering/consulting contractor specialising in industrial boiler plant and piping systems, becoming its Engineering Director in 1988 with particular responsibility for the company's interests in steam accumulation. In 1996, he became a founding partner and Technical Director in a new venture structured to provide consulting and project management services to the steam using industries.

He started his present consultancy in 2001 focusing on his specialist subject of steam accumulation and has established technology transfer agreements with associate companies in North and South America, Africa, India and Australasia. David has been responsible for the conception, development and implementation of a number of innovative steam accumulator control systems, some patented and others that have been adopted as standard solutions in steam storage projects. He has also written specialist papers on the subject, many of which have been published in industry journals.

If you want to find out more about steam accumulation visit the David Oakland Associates web site at:

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